Small-Packaged System Commissioning

How to eliminate many of the most common problems

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Editor's note: The New Buildings Institute (NBI) is conducting a Public Interest Energy Research (PIER) project for the California Energy Commission (CEC). NBI's project is called Integrated Energy Systems - Productivity and Buildings Science Program. As the name suggests, it is not individual building components, equipment or materials that optimize energy efficiency. Instead, energy efficiency is improved through the integrated design, construction and operation of building systems. One element of the overall project is examining integrated design of small HVAC systems in commercial buildings (specifically packaged rooftop units). This is the last article in a four-part series and will focus on commissioning of small HVAC systems.

As part of a California Energy Commission (CEC) study, engineers visited 40 new commercial buildings throughout California. A total of 140 packaged rooftop units were inspected and tested for proper operation and to identify problems that frequently occur. The findings in regards to commissioning are detailed in this article.

WHAT IS COMMISSIONING?

Commissioning is a quality-assurance process that increases the likelihood that a new building will meet the intent of the design team and, ultimately, the client's expectations. Although commissioning originally was created to ensure that HVAC systems were properly specified and installed, this process can be applied to virtually any building system.

The commissioning process encompasses the entire design and construction process:

- During the design phase, commissioning begins with the selection of a commissioning agent (CA).
- The designer incorporates commissioning requirements into the design specifications.
- During construction, the CA is responsible for inspecting the building to catch construction defects that are difficult to correct after the building is finished.
- When the project is near completion, the CA and contractors conduct performance tests of the systems to be commissioned.
- At the end of the commissioning process, the designer and vendors train the building operators how to properly operate and maintain the building.

At a minimum, commissioning should include documentation of the design intent, incorporation of commissioning testing in the building plans and specs, testing the system, correcting deficiencies, and providing operation and maintenance training to the building occupants. Incorporating the commissioning requirements into the specs is very important, since the contractor will base the bid on the plans and specs. Plus, setting the expectation that commissioning will be done will save a lot of trouble during the construction process.

This study identified a number of problems with HVAC systems that could have been identified and corrected with proper commissioning. Problems identified include broken economizers, fans running during unoccupied periods, fans that cycle on and off with a call for heating and cooling rather than providing continuous ventilation air, low air flow, inadequate ventilation air, and simultaneous heating and cooling. A summary of the findings from the study is shown in Figure 1.

COMMISSIONING CHECKLIST

Prior to conducting any commissioning tests, the units are inspected according to a checklist called a pre-functional checklist. Items on the checklist generally include:

❑ Document submittal (spec sheets, operations and maintenance instructions).

❑ Verification of make and model number.

❑ Installation checks, such as tight curb connections, operable cabinet door with gaskets in place, shipping materials and hold-downs removed, and adequate maintenance access.

❑ Duct insulation installed and in good condition.

❑ Filters installed properly.

❑ Fan motor aligned and belt tension correct.

❑ Economizer linkages tight, with smooth operation.

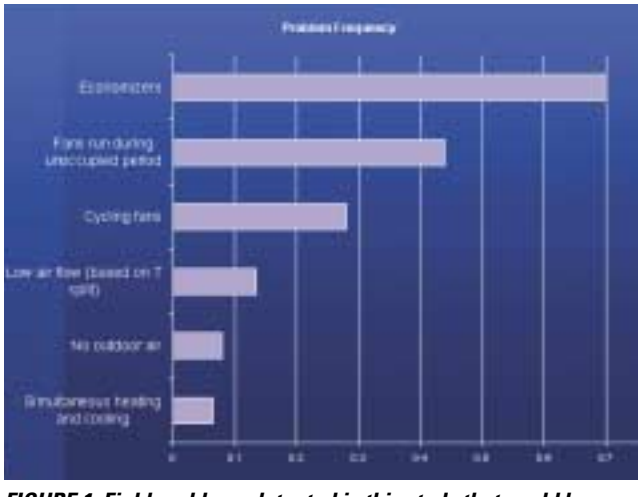

FIGURE 1. Field problems detected in this study that could have been caught with proper commissioning .

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❑ Safety disconnects properly installed.

TESTING 1-2-3

The heart of the commissioning process is a series of tests called functional performance tests. For small packaged units, functional performance testing usually includes:

• Cycling a unit through its various operating modes and observing unit response according to the control sequence of operations. Some questions to keep in mind during this test:

❑ Does the outdoor air damper close when the unit is turned off?

❑ Does the second compressor come on during a second stage call for cooling?

❑ Does the economizer actuator work? Photo A shows a unit that was installed on a small chain retail store. The unit was carefully maintained and operated except for a non-functioning economizer. A control board that interfaced the economizer actuator with a central-energy management system was missing from the unit. This is an example of a problem that could have been identified and corrected during commissioning.

❑ Do the dampers move freely over their full range?

❑ Are the sensors calibrated?

❑ Does the unit respond correctly when subjected to conditions where the economizer should operate?

• Verifying sensor calibration to ensure that room-temperature and supply-air temperature sensors are installed in a reasonable location and a calibrated.

• Verifying correct rotation of supply and condenser fan motors.

• Verifying that thermostat programming is correct, including fan controls:

❑ Are the set points and operating schedule correct according to the design documents?

❑ Does the fan run continuously during occupied hours?

Additional functional tests may also be included. These tests can detect less obvious but very important problems with HVAC installations:

• Check the air flow through unit . This generally requires the use of a flow grid to measure unit air flow.

• Verify that duct leakage is within acceptable limits. This generally requires the use of a duct pressurization device to measure duct leakage rate.

• Verify correct refrigerant charge. Refrigerant pressure measurements combined with refrigerant line temperatures to verify correct superheat (for fixed

PHOTO A. The control board for the economizer in this unit is missing.

throttling devices) or correct subcooling (for thermostatic expansion valve units)

• Verify adequate outdoor air flow. A flow grid can be used to make this measurement also.

QUALITY ASSURANCE

Due to an unfortunate perception of higher costs associated with the commissioning process, commissioning of small systems has yet to reach its full potential in the market. In most cases, the costs of commissioning are covered by reduced callbacks and quicker job completion. The resulting energy savings from fixing problem is a bonus.

One approach that is being considered in California is incorporating quality assurance testing into the energy code compliance process . One proposal under consideration by the CEC would require third-party verification of HVAC system installation and operation. The proposal includes testing requirements for outdoor air quantities, packaged-HVAC unit functional testing, economizer testing, duct-leakage verification, and lighting control tests. This proposal can help elevate the status of commissioning to a "standard operating procedure" in the construction of commercial buildings with small HVAC systems.

THE FUTURE

In this series, we have discussed a number of topics relating to the design, installation, operation, maintenance and commissioning of small HVAC systems. How can the industry avoid these problems in the future? These steps can improve the overall state of the art in small packaged HVAC systems:

• *Integrated design of the building and its systems.* Consider the design of the building as a series of interacting systems and design decisions, rather than as separate systems functioning independently of each other.

• *More robust engineering.* Price competition has driven the quality of some units and accessories down to the point where reliability is a concern, especially when it comes to economizers.

• *Fault-tolerant design.* Encourage design features that minimize the impact of system problems on the energy performance of the system.

• *Commissioning of systems as "standard operating procedure."* Encourage, through market forces or regulations, the testing and verification of HVAC system operation and performance

• *Improved maintenance procedures and technician training.* Adequate training is a key to improving the state of the art in unit maintenance. Unit designs that allow ease of repair can improve the effectiveness of service procedures.

• *Unit self-diagnostics.* There is a limit to what one can expect an HVAC service technician to accomplish during a service call. Built-in diagnostics can help the technician quickly and accurately diagnose and repair problems. Many problems go unnoticed by the occupants until they become so bad that the unit fails catastrophically. Diagnostic systems with occupant or service company alarm capability can help identify and fix problems before they get worse.

For more information on this research, visit *www.newbuildings.org/pier*.